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An evaluation of BLACK STAIN ROOT DISEASE on the GEORGETOWN DIVIDE El Dorado County

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AN EVALUATION OF BLACK STAIN ROOT DISEASE ON THE GEORGETOWN DIVIDE, EL DORADO COUNTY, CALIFORNIA

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The biological evaluation is based on survey data that will be published by Cobb and others. Statistics were calculated by Rowney. The evaluation and the development of management alternatives were done by Byler.

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INTRODUCTION

A rather high amount of ponderosa pine mortality has been recognized for many years on portions of the Georgetown Divide in El Dorado County, California. Bark beetles, mainly western pine beetle (Dendroctonus brevicomis) and mountain pine beetle (Dendroctonus ponderosae) are associated with this tree mortality. In 1964, the fungus Ceratocystis[1/] (Verticicladiella) wagenerii (cause of black stain root disease) was recognized as a cause of ponderosa pine mortality[2/] on the Divide (6).

In 1972, a survey was made of the ponderosa pine mortality on 28,544 acres of forested land on the Divide. The survey was done cooperatively by the University of California, Berkeley and Forest Insect and Disease Management, USDA Forest Service. Informational objectives of the survey needed to support this biological evaluation were to:

1) identify the causes of ponderosa pine mortality,

2) estimate the amount of the mortality, and

3) determine what stand and site conditions are contributing to the mortality.

This biological evaluation presents a summary of the survey results, discusses the biology of the major pests found to be involved (primarily the root pathogen), and suggests pest management alternatives for infested stands.

[1/] Ceratocystis is the recently discovered sexual stage.

[2/] C. wagenerii has also been found on Douglas-fir and rarely sugar pine and white fir. Infection of the latter two has not been of economic significance. However, since the initial discovery of black stain of Douglas-fir on the Divide (5), the disease has been found there in several scattered locations. We believe it bears watching, especially in the Sugar Pine Creek area.

SURVEY METHODS

The survey area is composed of 28,544 net acres of forested land in El Dorado County (Fig. 1). Forest cover is pure ponderosa pine stands, mixed conifer stands that contain a substantial amount of ponderosa pine along with incense-cedar, white fir, sugar pine, Douglas-fir and black oak, and stands that contain little ponderosa pine (Table 1). The stands are predominantly even-aged young growth about 60-80 years of age that resulted from logging and fires shortly after 1900. Michigan-Cal Lumber Company, the University of California (Blodgett Experimental Forest), and the Forest Service (Eldorado National Forest) are the major landowners.

TABLE 1 - Stand Species Composition of the 28,544 Acre Survey Area, as Determined from Aerial Photography Taken in June, 1972.

Species Composition	Acres
Pure Ponderosa Pine	1,488
Mixed Conifer; Ponderosa Pine Predominant	8,514
Mixed Conifer; Ponderosa Pine a Minor Species, but Represents 20% or More of the Stand	4,954
Mixed Conifer; Ponderosa Pine Represents Less Than 20% of the Stand	13,588
Total	28,544

The survey was made using aerial photographs and ground methods. True color transparencies of the entire survey area were taken in June of 1972, at a scale of 1:8000. Photos were examined stereoscopically by an experienced photo interpreter and all tree groups[1/] identified as

[1/] Most groups contained a few to many ponderosa pine that had been killed over a period of several years. Some "groups" contained single dead trees.

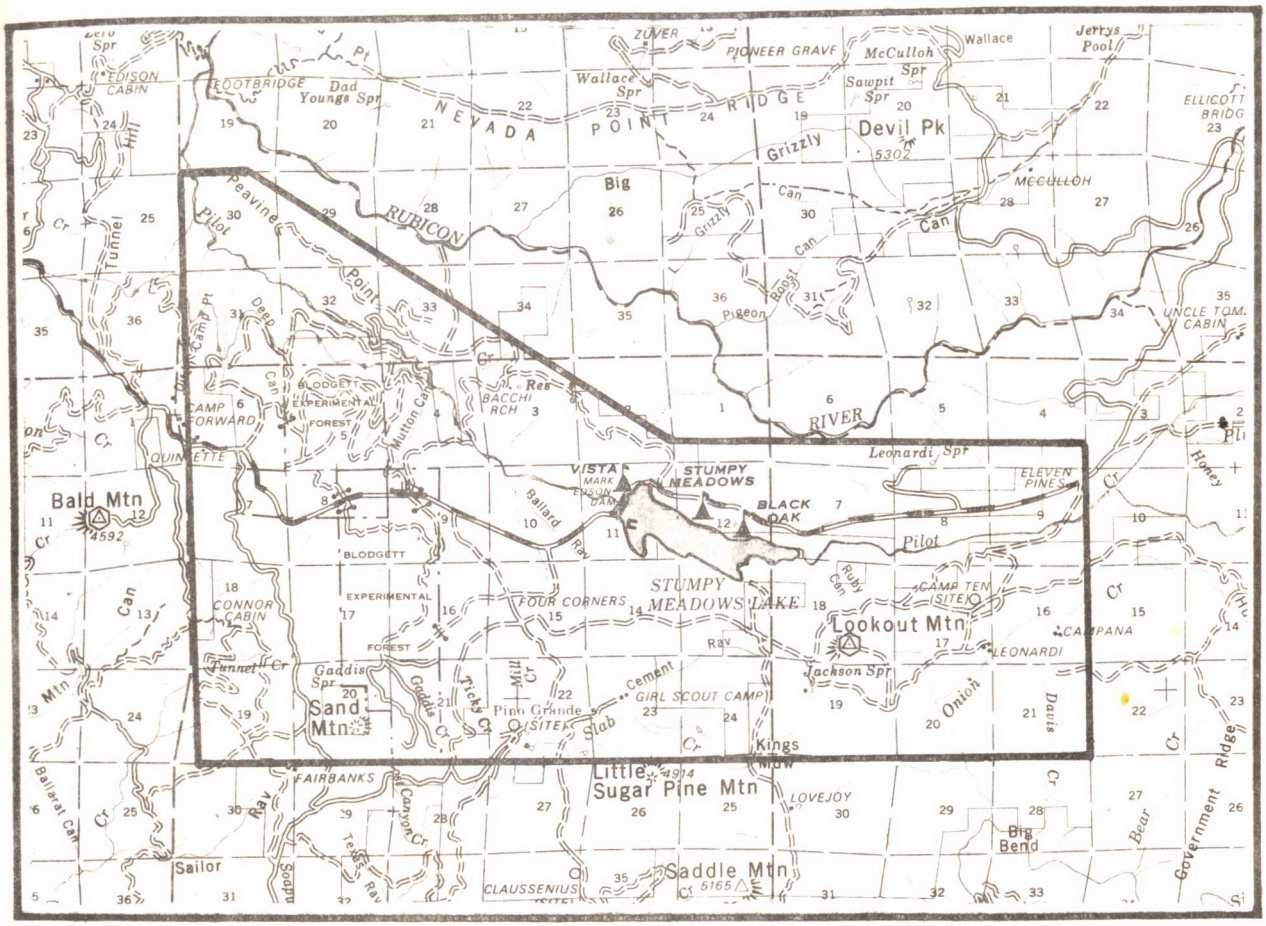

Figure 1. Location of the 28,544 acre area surveyed for ponderosa pine mortality in 1972.

dead or dying ponderosa pines were delineated on the photographs.

A stratified random sample of the dead ponderosa pine trees or groups identified on the photos were examined on the ground. Field crews recorded the area occupied by the dead pine groups, the size, number and crown color of all dead pines, and the pest or complex of pests associated with the pine mortality.

Data collected on the ground was summarized and the proportions of each pest complex found in the examined groups of dead trees were calculated. Number of trees, tree volumes and area occupied by the ground check groups were then expanded to give an estimate of all photo-detected ponderosa pine mortality in the entire survey area.

DISEASE DIAGNOSIS

The objective of the survey was to measure ponderosa pine mortality from all causes. But observations made prior to the survey suggested that a substantial proportion of the ponderosa pine mortality on the Divide occurs in black stain root disease centers.

Black stain root disease is diagnosed by means of dark brown-to-black stain in the roots, root crown and lower bole (Fig. 2). In cross section, the stain tends to occur in arcs that follow the annual rings. Other sapwood stains characteristically occur in wedge-shaped patterns.

The disease typically forms persistent centers of ponderosa pine mortality (Fig. 3). Infected, declining trees are sometimes present (Fig. 4).

Figure 2. Characteristic stain at the root crown and lower bole of a ponderosa pine caused by C. wageneriii. The stain is a black-to-brown streaking in the sapwood, and tends to occur in arcs that follow the annual rings. Stained wood is often impregnated with resin.

Figure 3. Large black stain root disease center. Dead trees, snags and live ponderosa pine with thinning crowns are visible at the center margin. Incense-cedar and white fir regeneration have replaced the young sawtimber-sized ponderosa pine within the center.

Figure 4. Declining ponderosa pines (center and left), dead pines (right) and unaffected pines (in the background). The thin crown of the center tree illustrates advanced black stain decline symptoms; shortened needles, poor needle retention, and reduced shoot growth.

RESULTS AND DISCUSSION

THE AMOUNT AND CAUSES OF PONDEROSA PINE MORTALITY

Tree mortality estimates are given in Table 2. An estimated 457 ponderosa pine mortality groups were present in the 28,544 acre survey area. These groups of dead ponderosa pines occupied a total area of 160 acres, and contained 39,300 trees with 651,000 cubic feet of wood.

Sixty percent of all dead tree groups (275 of 457) were in black stain root disease centers (Table 2). These centers contained 85 percent of the trees, 88 percent of the volume, and occupied 92 percent of the 160 acre area in dead tree groups. Average center size was 122 trees.

TABLE 2 - Total Ponderosa Pine Mortality and Black Stain Root Disease Associated Pine Mortality Over About a Ten Year Period.

	Number of Groups	Area of Groups (Acres)	Number of Trees	Tree Volumes (Cubic Feet)
Black Stain Root Disease	274 (60%)[2/]	147 (92%)	33,500 (85%)	571,000 (88%)
Other causes[1/]	183 (40%)	13 (8%)	5,800 (15%)	80,000 (12%)
Total (All Causes)	457 (100%)	160 (100%)	39,300 (100%)	651,000 (100%)

[1/] The proportion attributed to other causes were mainly single pines killed by western pine beetles, mountain pine beetles, or more commonly by both insect species.

[2/] Percent of total.

Insects infested most of the pine mortality that occurred outside root disease centers. They also infested and contributed to the death of pines with root disease. Galleries of western pine beetle, mountain pine beetle, or both were present in most ponderosa pine groups. Flatheaded borers (principally Melanophila californica) also attacked trees before their deaths. Occasionally, individual trees were infested by all three insect species.

Estimated number of trees and volumes include standing dead trees, standing snags and trees lying on the ground. Observations made in the area over the past decade suggest that the estimates include trees killed over a period of about 10 years. If so, the root disease/bark beetle complex has killed an average of 3,350 trees, or 57,000 cubic feet of wood per year. A similar estimate of the mortality (3,000 trees or 60,000 cubic feet) was obtained for the last year of the study (spring of 1971-spring of 1972), an estimate obtained using only recently faded trees. For the predominately ponderosa pine types with moderate-to-high stocking (about 5080 acres) the pine loss averaged about 12 cubic feet per acre per year, but in the dense pure pine the loss was several times as much. The 12 cubic foot loss resulted from an average level of infection of one center for every 19 acres in the type. An average of 12 trees with a total of 212 cubic feet of wood died per center per year.

CONTRIBUTING STAND AND SITE CONDITIONS

The occurrence of black stain root disease centers was related to stand species composition and stand density. Ninety-eight percent of the root disease occurred in stands that were either pure ponderosa pine, or predominately pine and had moderate to high stocking densities, (greater than 50% crown cover). Only 5,080 of the 28,544 acres were in these types. The Verticicladiella - associated ponderosa pine volume loss in these 5,080 acres was about 12 cubic feet per acre per year. The greatest loss occurred in pure pine stands, and in aggregations of pure pine within the mixed conifer. Resolution on type maps did not allow calculation of cubic feet loss for pure stands, but observations indicate that the loss was several times greater than 12 cubic feet/acre/year average.

Critical stocking densities have not yet been calculated. However, observations made in the survey area, and a more recent study (4) made in a 40 acre compartment within the area, indicate that C. wageneri damaged stands are densely stocked. The large proportion of the damage probably occurs in stands with stocking densities above the desired basal area of 215 square feet per acre.1/

1/ See the Timber Management Plan for the Eldorado National Forest, 1978-1987, 47p.

The age at which stands become susceptible to damage from the disease/insect complex is uncertain since most stands in the area are of a similar age (about 75 years old). However, back-dating of centers using sequential sets of aerial photos suggests that some centers were present as early as 1940 when the stands were about 35 years of age.

Several site factors appear correlated with damage caused by the pathogen/insect complex. Many of the largest and most rapidly expanding C. wagenerii centers occur on low-lying sites where soil moisture content is high in the spring. It has been postulated that high soil moisture favors the disease. In support of this, there is the result of an inoculation experiment where the greatest percentage of infected seedlings occurred in the wettest soil treatments (1).

Survey results showed that all the damage from the root disease/bark beetle complex was between 4,000 and 5,000 feet. A disproportionately high number of centers, in comparison to the acreage, occurred in the 4200-4600 foot elevational zone. It is unclear why the fungus has not been found in ponderosa pine below 4000 feet on the Divide.

BIOLOGY OF THE ROOT PATHOGEN AND INSECTS

Recent research on the pathogen, insects, and insect-pathogen relationships has shed light on the process that is taking place.

The pathogen initially becomes established in the roots and root crown of a susceptible ponderosa pine, probably via long-distance transmission by an insect vector. Hylastes macer may be an important vector in ponderosa pine (2). The fungus alone is capable of killing trees but more commonly, as the results of this survey suggest, western pine beetle and mountain pine beetle attack and kill the diseased trees. Goheen (2) found that insects were much more likely to infest and kill black stain infected than uninfected trees, and among diseased trees, the insects were more successful on those that were in advanced stages of disease.

The fungus spreads from the initially infected tree to adjacent trees creating a "center" of diseased trees that subsequently are infested and killed by the insects. This short range tree-to-tree spread appears to occasionally occur across grafts and major root contacts, but the fungus much more commonly enters roots through small rootlets (2). The means by which the fungus is carried from diseased roots or rootlets to rootlets on non-diseased trees is not known but recent studies (3) have shown that the fungus can exist in soils and apparently can grow short distances (a few inches) through soil. Centers of disease and mortality continue to spread radially until they encounter limiting conditions, usually a timber type change. Centers as large as 60 acres (the "Gaddis Creek Center") are known to occur on the Georgetown Divide.

Examination of several sets of aerial photographs taken periodically from 1963-1974 indicated that new infections were infrequent. About three new centers per year were detected on the 28,544 acre survey area during that period.

The rate of center enlargement was also measured using aerial photographs taken over the same period of 11 years. Average annual radial spread of 54 centers in all stand classes was 4 feet, but spread rates varied with stand density, species composition and site. Some centers did not spread at all. For those that did, the slowest average rate of spread, about 1 foot per year, was in mixed conifer stands with relatively low stocking densities growing on dry sites. The greatest average rate for any stand class, about 6 feet per year, was for dense stands of pure pine growing on wet sites. The rate in a few individual centers approached 20 feet per year.

Root excavations have shown that advance of the pathogen through roots preceeds above ground symptom expression. Infected, stained roots can be present in apparently healthy trees 50-60 feet from symptomatic trees.

The insects and disease typically kill most of the susceptible ponderosa pines within a center.

MANAGEMENT ALTERNATIVES

With the preceding information as a background we find the following alternatives available for the management of presently infested stands.

1. Do Nothing. Mortality will continue. The fungus will continue to spread from existing centers into susceptible stands. Ponderosa pines on the margins of these centers will decline from the disease and be killed following attack by beetles. Many centers will regenerate naturally with resistant tree species. Wood volumes from dead and dying pines will be lost, an estimated loss of 12 cubic feet/acre/year average for all well stocked stands with ponderosa pine, and a much higher volume loss for pure pine stands.[1/]

[1/] On the Georgetown Divide such centers often become stocked naturally with non- or less-susceptible species, usually white fir, incense cedar, and sugar pine. The net result is a conversion of predominantly ponderosa pine stands to stands that are predominantly non-pine, and the loss of wood from pines not salvageable.

2. Salvage Trees as They Die. Rates of disease spread and tree mortality will not be changed by the treatment. Wood in the dead trees will be recovered. Annual or semi-annual entries will be required to remove the dead trees before they decay.

3. Cut Dead Trees and Living Trees Showing Disease Symptoms. This treatment will not prevent disease spread since the fungus will have already spread to trees that do not yet show symptoms. But the treatment will reduce the frequency of stand entries, and harvesting some green trees will increase sale stumpage value.

4. Cut Dead Trees, Diseased Trees and a Buffer Strip of Healthy Ponderosa Pine. This option will accomplish the salvage goals of the above treatments. In addition, it should reduce future damage in the stands. The cutting of all apparently healthy pines within 75 feet or more of visibility infected pines on center margins should substantially reduce progress of the fungus into healthy stands, since it appears that the fungus does not spread through root systems of dead trees. Regeneration of cut areas with resistant tree species will minimize future damage from the pathogen/insect complex. Incense-cedar, white fir or hardwoods are the most resistant of the species native to the area. Sugar pine and Douglas-fir should be used in centers where only ponderosa pine is being killed and if more resistant species are not suitable.[1/]

5. Salvage and Sanitize the Mortality Centers and Commercially Thin the Adjacent Stands. This treatment option is like the previous one, but it includes a thinning of the entire stand. Current and most future mortality will be harvested in one cut. Future impact of the disease/insect complex and insect alone will be reduced by cutting the buffer strips, and stand conditions that favor damage caused by this complex can be alleviated by reducing the stocking density and favoring a mixed species composition. The current Timber Management Plan calls for a desired stocking density of 215 square feet. Most of the mortality appears to be in stands with greater densities than this level.

[1/] Sugar pine is probably less apt to become infected than Douglas-fir. Sugar pine appears quite resistant, and considering the exposure, becomes infected only rarely in the field. Douglas-fir is more frequently infected, but the disease does not appear to spread readily from ponderosa pine to Douglas-fir.

Future damage from the black stain root disease/bark beetle complex may be prevented by the treatment of stands before they reach the susceptible stages.

1. Regenerate With Mixed or Resistant Tree Species. Nearly all of the C. wageneri occurred in stands of pure ponderosa pine, or aggregations of pure pine in mixed conifer stands. It appears prudent not to regenerate areas known to have C. wageneri with pure stands of ponderosa pine.

2. Thin Stands to Control Stocking Densities and to Achieve a Mixed Species Composition. Early treatment of stands will reduce black stain and insect mortality by reducing stocking levels and maintaining a mixed species composition.

LITERATURE CITED

1. Goheen, D.J. and F.W. Cobb, Jr. 1974. Soil moisture as a factor affecting infection of ponderosa pine by Verticicladiella wagenerii. Proc. Amer. Phytopath. Soc. 1:111.

2. Goheen, D.J. 1976. Verticicladiella wagenerii on Pinus ponderosa: Epidemiology and Interrelationships with Insects. Ph.D. Dissertation , Univ. of Calif. Berkeley. 118p.

3. Hicks, B.R. 1973. Growth of Verticicladiella wagenerii through soil and infection of Pinus ponderosae as related to selected soil properties. MS Dissertation, Univ. of Calif. Berkeley. 134p.

4. Lane, J., R.D. Heald, E.C. Stone, D.L. Dahlsten and R. Akers. 1978. Silvicultural treatment to reduce losses to bark beetles. California Agriculture, 32(7):12-13.

5. Miller, D.R. and E.I. Viers. 1968. Verticicladiella wagenerii found on Douglas-fir in El Dorado County, California. Plant Dis. Reporter 52(5):393.

6. Stark, R.W. and F.W. Cobb , Jr. 1969. Smog injury, root disease and bark beetle damage in ponderosa pine. Calif. Agric. 23:13-16.

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